REPORT OF SURVEY CONDUCTED AT

ENGINEERED CIRCUIT RESEARCH, INC.

MILPITAS, CALIFORNIA

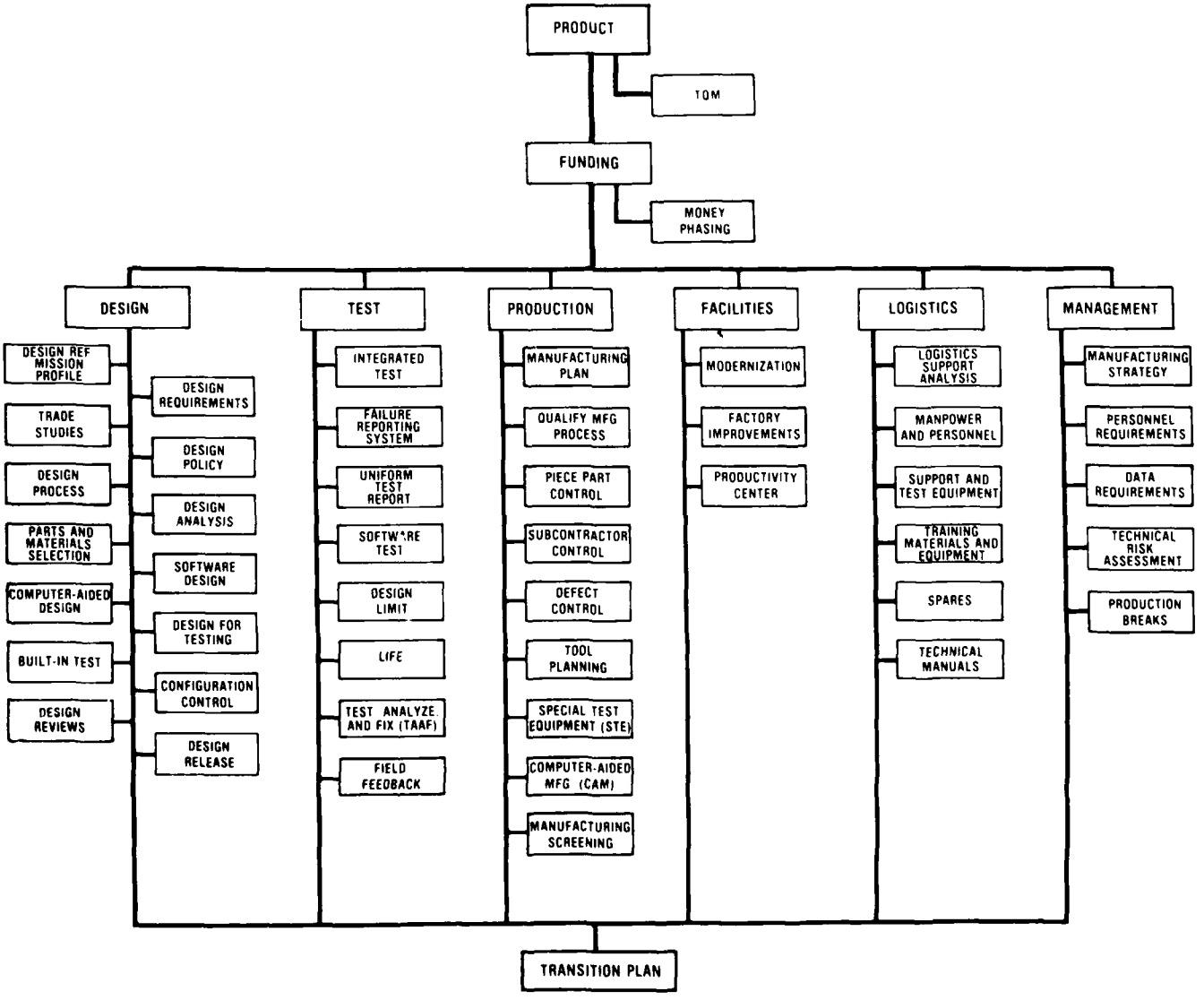
JULY 1989

BMP

DoD 4245.7-M

"TRANSITION FROM DEVELOPMENT TO PRODUCTION"

CRITICAL PATH TEMPLATES



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SECTION 1

EXECUTIVE SUMMARY

The Best Manufacturing Practices (BMP) Program team conducted a survey at Engineered Circuit Research (ECR), Inc., located in Milpitas, California.

The purpose of the survey was to review and document the best practices and potential industry-wide problems at ECR. The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry.

1.1 KEY FINDINGS

Many best practices were observed at ECR and are detailed in this report. Some of the most significant findings are summarized below.

ITEM	PAGE
Prototype Assembly Production equipment and processes are used to assure manufacturability.	5
Fine Pitched Device Manufacturing Effective capabilities for successful manufacturing of fine pitch devices are presented.	5
Solder Reflow Variety A variety of reflow techniques are used to optimize solder joint quality and integrity in specific applications.	6
Business Philosophy The company focuses on up-front quality to add value for the customer.	7
Strategic Partnerships These partnerships allow ECR to focus on what it does best - surface mount technology manufacturing.	7

SECTION 2
INTRODUCTION

2.1 SCOPE

The Best Manufacturing Practices (BMP) survey conducted at ECR is the second small business survey conducted in the BMP program. These companies, which account for a significant portion of defense spending, have much to offer in innovative practices.

The purpose of the BMP surveys is to identify best practices, review manufacturing problems, and document the results. The intent of these reviews is to extend the practice of progressive management techniques and the use of high technology equipment and processes throughout industry. BMP's ultimate goal is two-fold: to reduce the life cycle cost of defense systems and to strengthen the U.S. industrial base. This goal is realized through the use of techniques and technologies to solve manufacturing problems and to improve quality and reliability.

In support of the BMP goal, a team of Navy engineers accepted an invitation from ECR to review and document the advanced manufacturing processes and techniques used at their facility in Milpitas, California. The survey was conducted on 13-14 July 1989 by the team identified in Appendix B.

The results of BMP surveys are entered into a database to track the best practices currently available and common manufacturing problems identified by industry. The information from the surveys is available for dissemination through this easily accessible computer database. The actual exchange of detailed technical data takes place between companies at their discretion on a strictly voluntary basis.

The results of this survey should not be used to rate ECR among other defense contractors. A contractor's willingness to participate in the BMP program and the survey results have no bearing on one contractor's performance over another's. *The documentation in this report and other BMP reports is not intended to be all-inclusive of a contractor's best practices and problems. Only selected nonproprietary practices are reviewed and documented by the BMP survey team.*

The process of selecting topics which are documented as best practices is subjective and is partially determined based on company-selected topics presented during the survey. Best practices are also selected by the survey team members' evaluations based on personal experience and observations at other companies. With the addition of small business surveys to the BMP program, best practices were evaluated from a small-company perspective. What might have been considered a best practice for a small company of limited resources may not have been considered a best practice in a large company with greater resources and capabilities. The innovative use of limited resources by a small company was regarded as a possible best practice. Based on these ideas, the survey team found that ECR did indeed have some best practices to share.

2.2 SURVEY PROCESS

This survey was performed under the general survey guidelines established by the Department of the Navy. Survey concentration was on the functional areas of design, test, production, facilities, logistics, and management. The team evaluated ECR's policies, practices, and strategies in these areas. Individual practices reviewed were also characterized as they relate to the critical path templates of DoD 4245.7-M, "Transition from Development to Production." ECR identified potential best practices and industry-wide problems. These and other topics were discussed, reviewed, and documented for distribution throughout the U.S. industrial base.

The survey format included formal briefings and discussions on best practices and problems. Team members spent time on the production floor reviewing practices, processes, and equipment. In-depth discussions were conducted to more completely understand and document the identified best practices and problems.

2.3 NAVY CENTERS OF EXCELLENCE

Demonstrated industry-wide problems identified during the BMP surveys may be referred to one of the Navy's Centers of Excellence listed below.

- Electronics Manufacturing Productivity Facility (EMPF) - Ridgecrest, CA

  The EMPF conducts applied research in the processes and materials involved in the manufacture of circuit card assemblies.

- Metalworking Technology Incorporated (MTI) Johnstown, PA

  MTI conducts applied research in the metalworking processes.

- Automated Manufacturing Research Facility (AMRF) - Gaithersburg, MD

  The AMRF conducts applied research in the machining processes within a heterogeneous computer integrated manufacturing environment.

2.4 ENGINEERED CIRCUIT RESEARCH OVERVIEW

ECR was founded in 1984 to utilize advanced materials and processes in the manufacture of surface mount technology (SMT) for commercial, military, and aerospace applications. To maintain a state-of-the-art capability, the company continually funds significant research and development programs to examine key SMT manufacturing issues and develop effective solutions for identified problems. Besides providing SMT assembly and related services, ECR assists customers in design, research and development, education, and problem solving.

In the design stage, ECR works with customer engineers and designers to specify components, component packaging, component lead metalizations, substrate, layout rules, and other items that will ultimately affect the reliability, manufacturability, and quality of the assembly. Reliability testing through thermal, power, vibration, and humidity cycling is encouraged to optimize the reliability and manufacturability of the product design before entering the production phase.

The central objective of ECR's manufacturing operation is to optimally manufacture the product the first time, thereby improving reliability and minimizing costly scrap and rework. ECR functions on the belief that the difficult quality work should be completed prior to the start of production, then proper control of the manufacturing process should produce a defect-free product. This philosophy represents ECR's commitment to quality and the elimination of problems before they affect the manufacturing process.

2.5 ACKNOWLEDGMENTS

Special thanks are due to all the people at ECR whose participation made this survey possible. The BMP team particularly acknowledges the special efforts of Mr. Ron Rapczynski, Vice-President of ECR. His enthusiastic support of the BMP team during all phases of the survey was greatly appreciated, and his dedication significantly affected the survey's success.

2.6 ENGINEERED CIRCUIT RESEARCH POINT OF CONTACT

While the information included in this report is intended to be descriptive of the best practices observed at ECR, it is not intended to be all-inclusive. More detailed information on a particular topic can be obtained by contacting the company directly. Any exchange of technology or data resulting from such contact is strictly voluntary and at the discretion of ECR.

The point of contact at Engineered Circuit Research, Inc. for the Best Manufacturing Practices Program is:

Mr. Ron Rapczynski, Vice-President
Engineered Circuit Research, Inc.
1525 McCandless Drive
Milpitas, California
Telephone: (408) 263-7171

SECTION 3
BEST PRACTICES

3.1 DESIGN

DESIGN PROCESS

Manufacturing Specialization

ECR's customers frequently require design and test services. Consequently, ECR works with a few select companies who perform these functions. This specialization allows ECR to focus on its expert area of SMT manufacturability. ECR works closely with its design and test subcontractors to ensure that the customer's needs are met. This relationship involves training and communicating design-for-producibility guidelines.

Advances in electronic hardware complexity, difficulty in state-of-the-art equipment maintenance, and upgrading technology in multidiscipline areas demands specialization. The specialization in SMT manufacturing while supporting relationships with design and test support companies helps maintain ECR's competitive edge in contract manufacturing.

Design Development

Customers are encouraged by ECR to communicate with them early in the design stage. This initial contact is productive, influencing the design at the earliest stages to facilitate trouble-free transition from development to production. This practice, in turn, leads to a low cost, high yield product. ECR recognizes the importance of proper design and works extensively with the customer to optimize designs for producibility. ECR guides the company in deciding how to apply SMT to the product by using four criteria: product size, reliability, cost, and component functionality. This focus allows for clear decisions to be made in trade-offs encountered in the design development.

3.2 PRODUCTION

QUALIFY MANUFACTURING PROCESSES

Prototype Assembly

As a contract manufacturing house, ECR is periodically tasked to assemble very low volume prototype assemblies. ECR uses this opportunity to learn as much as possible about the manufacturability of an item, using actual production equipment and processes in manufacturing the prototype. Resulting feedback is used to improve the assembly's design and manufacturing processes. This closed loop process results in a high yield, manufacturable product for ECR, and a lower cost, higher quality product for the customer.

DEFECT CONTROL

Fine Pitched Devices

One area of interest in the electronics industry is the increasing packaging density caused by using components with high pin counts and very fine pitch. In response to a customer need, ECR developed a process for lead preforming for a range of quad type flatpacks, up to a 172-pin 25-mil pitch package. ECR is continually improving this capability since good quality lead forming on these devices is crucial to successful fine-pitch manufacturing.

In addition to component preparation capabilities, ECR uses several soldering processes for different manufacturing applications. The preferred method in industry for fine-pitch device soldering is the "hot bar" technique. Utilizing the solder from leads of a hot solder dipped device and/or the board plating, ECR is achieving excellent results on devices up to 340 pins with 20-mil pitch.

Equipment Process Control

ECR carefully controls the operation of several pieces of equipment. These operations include solder paste screening and pick-and-place machine setup.

A 10% sampling of each run undergoes a four-point inspection procedure in the screen printing operation by checking four paste parameters and recording the serial number as pass or fail. This procedure permits the operator to print consistently and prevent printing operation related defects.

An effective procedure for pick-and-place machine setup has been instituted by ECR. The initial pick-and-place machine setup is followed by a second operator verifying the setup. Components are then placed on one board after which an inspector will ensure placement accuracy. After verification is finalized, the remaining boards are assembled.

Solder Reflow Variety

Because of the variety and complexity of manufactured board assemblies, ECR uses several available solder reflow techniques. Hot bar reflow is used for fine pitch flatpacks with cannot be effectively reflowed by traditional means. Assemblies which contain components of uniform mass are reflowed with a Vitronics Infrared/convection reflow oven. An HTC batch vapor phase is utilized for components of varying mass. A dual wave solder machine is used for through-hole component soldering or soldering of passive components on double-sided SMT boards. For special components that cannot be reflowed by any of the other methods, hand soldering is still applied.

This mixture of solder reflow techniques is a best practice because assemblies are reflowed with the technique that optimizes solder joint quality and integrity.

Static Discharge Control

ECR is conscious of component damage resulting from electrostatic effects; therefore, significant control methods are employed and stringently maintained. The staticide-coated production floor is stripped and recoated monthly. Workbenches made of conductive Formica™ are stuffed with conductive foam material. Conductive mats and wrist or boot straps are also used, and the straps are tested daily to ensure effective use. Travelers are placed in poly bags to prevent possible static generated from the paper. These representative precautions installed by ECR are necessary to prevent the unnecessary and time-consuming assembly rework.

Solder Paste

ECR is currently benefiting from some of the company's early research with solder paste. This research led to the development of new flux binders for solder pastes which ECR is now using in its production line. These advances in material science, together with ECR's knowledge of process controls involved with screen and stencil printing, has contributed to the elimination of solder balls and other solderability problems. Procedures in controlled solder paste use have also aided in providing good solder paste application.

In-Process Inspection

In-process inspection constitutes 80% of ECR's inspection operation. Procedures are based on the rule that board assemblies are inspected before and after any soldering process. The quality engineering staff completes a first-pass yield report on a sample size determined by a MIL-STD-105D sampling table. Anomalies are separated into the solder defect and component defect categories. The procedure is consistently performed and easily pinpoints at which point in the process defects occur. The required process adjustments are therefore highlighted and incorporated. Inspection points are physically located in the plant layout as "gates" that are impossible to bypass. This unique system feature significantly contributes to the 95% or better yield that is maintained as a result of using this in-process inspection process.

3.3 FACILITIES

FACTORY IMPROVEMENTS

Surface Mount Device Pick and Place

ECR has successfully used two PERMAX VMP 1000 automatic surface mount device placement machines since June 1988. Most of the placement programs can be written off-line, and program fine-tuning is performed with a focused LED and a vision system. Components are fed with tubes or tape and reel. ECR has modified the VMP 1000 to increase the maximum board size beyond equipment specifications to a 19-inch by 16-inch substrate. Many assembled boards use a common fixture size to minimize or eliminate changeover time resulting from fixturing. ECR's total placement capability can accommodate almost 90,000 components per day.

Production Floor Layout

ECR has arranged its production floor to closely replicate the product assembly path. This layout is based on a U-shape arrangement, with double-sided boards proceeding twice through the necessary portions of the "U." The obvious benefit to the new layout is reduced confusion while tracking in-process work. The boards are clearly

visible at any given point in the process, and less time is spent moving material from one point to another. This layout also allows for strategically placed inspection areas.

3.4 MANAGEMENT

MANUFACTURING STRATEGY

Business Philosophy

ECR is a highly focused company specializing in SMT and related technologies with particular emphasis on SMT manufacturability. The company philosophy is to establish long-term relationships with its customers, becoming involved in the early stages of product concept and development. ECR hopes to contribute to design consultation, research and development, education, and problem solving to add significant value to the customer's products. Early process involvement affects the end-item quality, reliability, and manufacturability through component specifications, lead metalizations, substrates, and layout rules.

ECR directs considerable effort toward SMT application education. Results from this education lead to manufacturing the product right the first time, thereby reducing rework and increasing assembly reliability. ECR assists the customer in determining if SMT is the correct application for the product and helps establish priorities used to make design trade-offs. This process helps establish philosophical compatibility with the customer in manufacturability design.

Early product development involvement, ensuring manufacturability, and emphasizing defect-free production all represent ECR's commitment to quality. This commitment is a best practice, particularly in a small company where the daily business pressures can lead to technical compromises affecting product quality.

Strategic Partnerships

ECR is a contract manufacturer offering customers a state-of-the-art manufacturing capability. It also has the flexibility to manufacture a variety of products in diverse volumes and handle the requirements of many different original equipment manufacturers. Focusing on SMT manufacturing allows ECR to research and implement advanced manufacturing techniques more rapidly than original equipment manufacturers with other business concerns. This process reduces product time to market by releasing resources in companies with design and marketing proficiency.

To provide these services, ECR has developed strategic partnerships with customers and suppliers, thereby enabling the company to focus on SMT manufacturing, its recognized area of expertise. ECR has established long term arrangements with companies who function not only as suppliers but also as consultants and strategists. ECR is involved in product design and producibility development in this capacity, using their technological expertise to minimize product cost and improve quality and reliability. The materials and components used by ECR are supplied on consignment by the customer and are prekitted. This unique aspect allows ECR to not require a sophisticated material review process system and the requisite administrative costs of procuring, testing, and handling piece parts. The savings are passed on to the customer.

Another example of ECR's strategic relationships is demonstrated by the company's decision not to invest in computer-aided design systems and expensive test equipment. These services are subcontracted, when required, to a few selected companies with whom ECR has developed close working relationships. Again, this option permits ECR to focus its resources on manufacturing, providing benefits in cash flow and return on assets, aspects which are important to a small company.

APPENDIX A

LIST OF ACRONYMS

BMP	Best Manufacturing Practices
ECR	Engineered Circuit Research
SMT	Surface Mount Technology

APPENDIX B

BMP REVIEW TEAM

TEAM MEMBER	AGENCY	ROLE
CDR Rick Purcell (202) 692-3422	Office of the Assistant Secretary of the Navy RM&QA-PI (S&L) Washington, DC	Team Chairman Management and Logistics
Dave Rubinic (619) 446-7706	Electronics Manufacturing Productivity Facility Ridgecrest, CA	Design and Test
May Kay Zeunik (317) 353-3714	Naval Avionics Center Indianapolis, IN	Production and Facilities

APPENDIX C

PREVIOUSLY CONDUCTED BMP SURVEYS

BMP surveys have been conducted at the companies listed below. Copies of survey reports for any of these companies may be obtained by contacting:

Best Manufacturing Practices Program
Office of the Assistant Secretary of the Navy
(Shipbuilding and Logistics)
Attn: Mr. Ernie Renner, RM&QA
Washington, DC 20360-5100
Telephone: (202) 692-0121

Litton
Guidance & Control Systems Division
Woodland Hills, CA
October 1985

Texas Instruments
Defense Systems & Electronics Group
Lewisville, TX
May 1986

Harris Corporation
Government Support Systems Division
Syosset, NY
September 1986

Control Data Corporation
Government Systems Group
Minneapolis, MN
December 1986

ITT
Government Systems Group
Clifton, NJ
September 1987

UNISYS
Computer Systems Division
St. Paul, MN
November 1987

General Dynamics
Fort Worth Division
Fort Worth, TX
May 1988

Honeywell, Inc.
Underseas Systems Division
Hopkins, MN
January 1986

General Dynamics
Pomona Division
Pomona, CA
August 1986

IBM Corporation
Federal Systems Division
Owego, NY
October 1986

Hughes Aircraft Company
Radar Systems Group
Los Angeles, CA
January 1987

Rockwell International Corporation
Collins Defense Communications
Cedar Rapids, IA
October 1987

Motorola
Government Electronics Group
Scottsdale, AZ
March 1988

Texas Instruments
Defense Systems & Electronics Group
Dallas, TX
June 1988

Hughes Aircraft Company
Missile Systems Group
Tucson, AZ
August 1988

Litton
Data Systems Division
Van Nuys, CA
October 1988

McDonnell Aircraft Company
St. Louis, MO
January 1989

Litton Systems, Inc.
Applied Technology Division
San Jose, CA
April 1989

Standard Industries
La Mirada, CA
June 1989

Bell Helicopter
Textron, Inc.
Fort Worth, TX
October 1988

GTE
C3 Systems Sector
Needham Heights, MA
November 1988

Northrop Corporation
Aircraft Division
Hawthrone, CA
March 1989

Litton Systems, Inc.
Litton Amecon
College Park, MD
June 1989

Information gathered from all BMP surveys is included in the Best Manufacturing Practices Management Informatic . System (BMP-MIS). Additionally, a calendar of events and other relevant information are included in this system. All inquire regarding the BMP-MIS may be directed to:

Director, Naval Industrial Resources Support Activity
Attn: BMP-MIS System Administrator
Bldg. 75-2, Room 209, Naval Base Philadelphia, PA 19112-5078
Telephone: (215) 897-6684

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The purpose of the Best Manufacturing Practices (BMP) survey conducted at this facility was to identify their best practices, review manufacturing problems, and document the results. The intent is to extend the use of progressive management techniques as well as high technology equipment and processes throughout the U.S. industrial base. The actual exchange of detailed data will be between contractors at their discretion. A company point of contact is listed in the report

The intent of the BMP program is to use this documentation as the initial step in a voluntary technology sharing process among the industry. JRS

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